Civil & Commercial Applications Project (CCAP): Evaluation of IKONOS Pan, MSI, and Pan-Sharpened Imagery for Suitability to Feature Extraction Tasks

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March 26th, 2002

High Spatial Resolution Commercial Imagery Workshop

Study Objectives

- Quantify the utility of IKONOS Pan, MSI, and Pan-sharpened imagery for basic NIMA mapping applications
  - Information content of IKONOS imagery in support of standard feature extraction and attribute assignment tasks
- Compare utility between image types
  - Lower resolution MSI to higher resolution Pan
  - Similar resolution Pan and Pan-sharpened
- Use the same imagery matrix as in interpretability study
  - Four climatic regions
  - Variety of scene content

Approach

- Data were analyzed to determine the utility of IKONOS imagery products for the extraction of cartographic features needed to create standard NIMA mapping products
  - Categories derived from the Feature and Attribute Coding Catalog (FACC)
- Feature extraction questions solicit the analyst's confidence their ability to extract a given feature
- Attribute questions solicit the analyst's ability to characterize a given feature

Feature Selection

- Features considered for this evaluation fall into broad coverage categories as listed in the FACC
- Some overlap of features between coverage categories
  - Features were selected so as to minimize this redundancy
- All the ratings provided for features that fell into a particular coverage category were averaged for each product type
  - Allows comparisons of products by general mapping application criteria
- 32 Level 1 Pan scenes used to create 128 image chips
- 32 Level 1 MSI scenes used to create 128 image chips
- 12 Level 1 Pan-sharpened scenes used to create 30 image chips

Feature Categories

Category	Number of Features
Boundary	4
Ground Obstacle	8
Hydrography	50
Industrial	26
Population	44
Surface Material Composition (SMC)	4
Transportation	56
Utility	16
Vegetation	20
Total	**228**

Methodology

- Conducted at NIMA/ASAI's softcopy evaluation facility
- All evaluation participants used workstations with calibrated precision color monitors
- Each participant reviewed a sequence of scenes
  - Provided a confidence rating (0-100) on their ability to extract a given feature
  - Once a response was given, the evaluation software displayed the image chip with a vector annotation around the feature in question
  - A series of multiple choice and yes/no questions were then asked about the attributes associated with that feature
- Image sets were randomly displayed for any given feature, with the caveat that Pan-sharpened imagery was displayed last
  - True and False Color Composites displayed side-by-side

Analysis

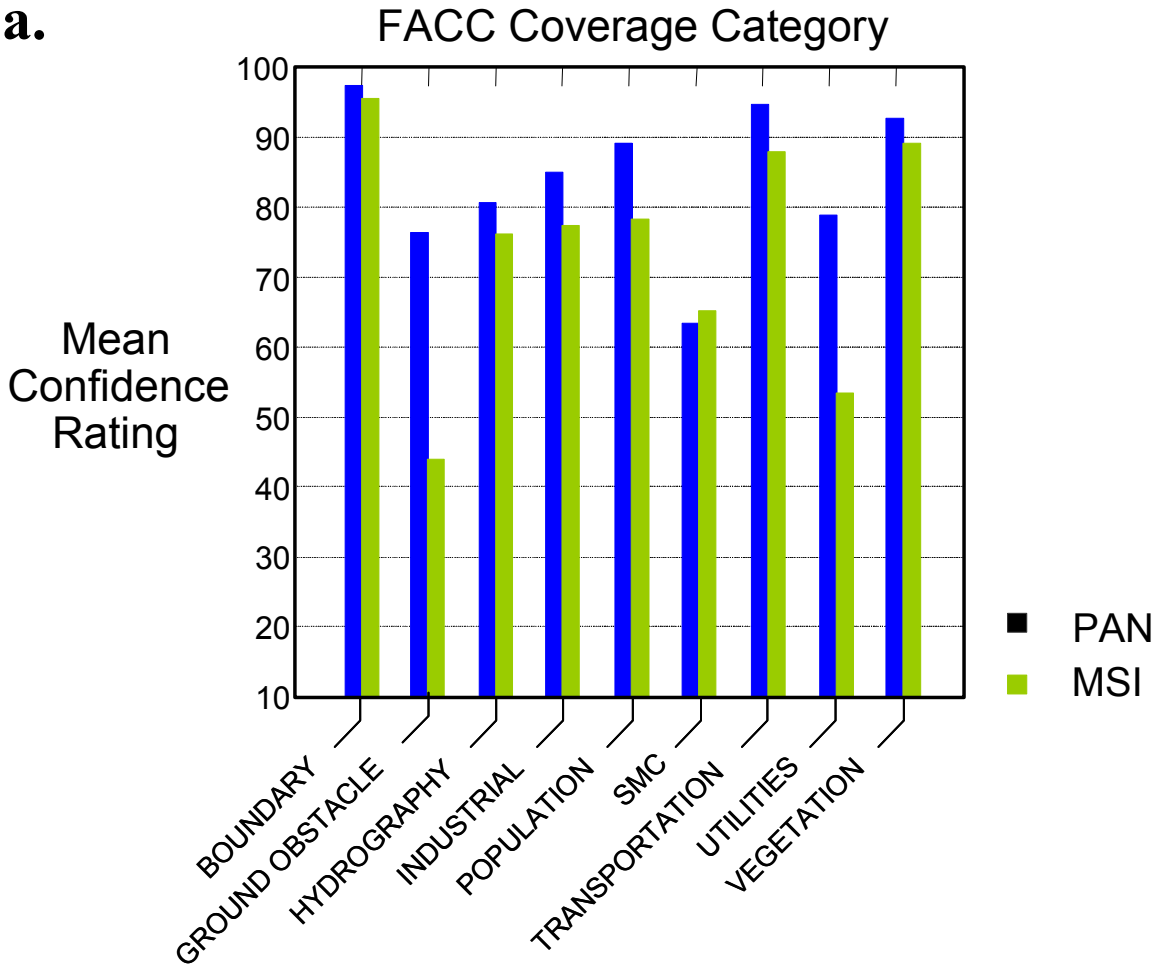
- Twelve Geospatial Analysts/Cartographers
  - 660 confidence ratings
  - 1822 attribute responses
- As in the analysis of IA responses, the data were analyzed to identify and remove any outliers
  - No outliers were identified
- Two approaches to the statistical analysis of data were then taken
  - Analyst confidence ratings for feature extraction by FACC coverage category
  - Analyst responses (confidence ratings and attribute responses) against the independent variables (image type and climate)

Pan vs. MSI

- Boundary category had the highest mean confidence response for both image types
  - 97% for the Pan image type
  - 96% for the MSI image type
- Utility exhibited significant difference between image type
  - 79% mean confidence for Pan
  - 53% mean confidence for MSI
- Pan received the lowest mean confidence ratings in the Surface Material Composition (SMC) category (63%)
- MSI received the lowest confidence ratings in the Ground Obstacle category (44%)
  - Notable difference in responses between image types
    - 76% mean confidence for Pan

Feature Extraction
Mean Confidence, Pan vs. MSI

a.

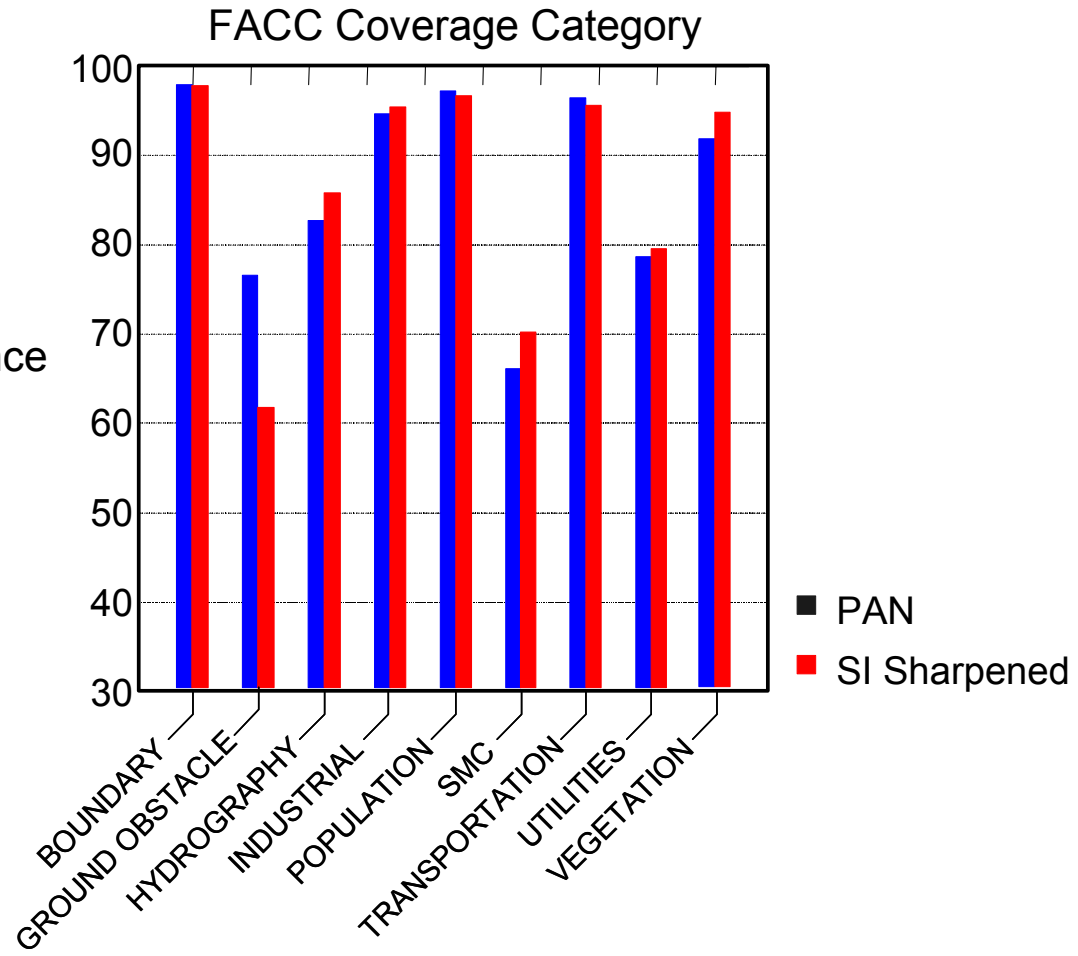


Pan vs. Pan-sharpened

- In most categories, Pan-sharpened image types performed in similar fashion to the Pan image types
  - Fewer Pan-sharpened image chips to satisfy all coverage categories
  - Some coverage categories were represented by as few as one Pan-sharpened image chip (SMC)
- Boundary coverage category received the highest confidence ratings in both image types
  - 97% for Pan and Pan-sharpened
  - Only three sharpened image chips tasked against it,
- Ground Obstacle category received the lowest mean ratings for the Pan-sharpened image types
  - Single category that exhibited a notable difference between the two image types
  - Only three Pan-sharpened MSI image chips were represented in that coverage category

Feature Extraction
Mean Confidence, Pan vs. Sharpened

b.



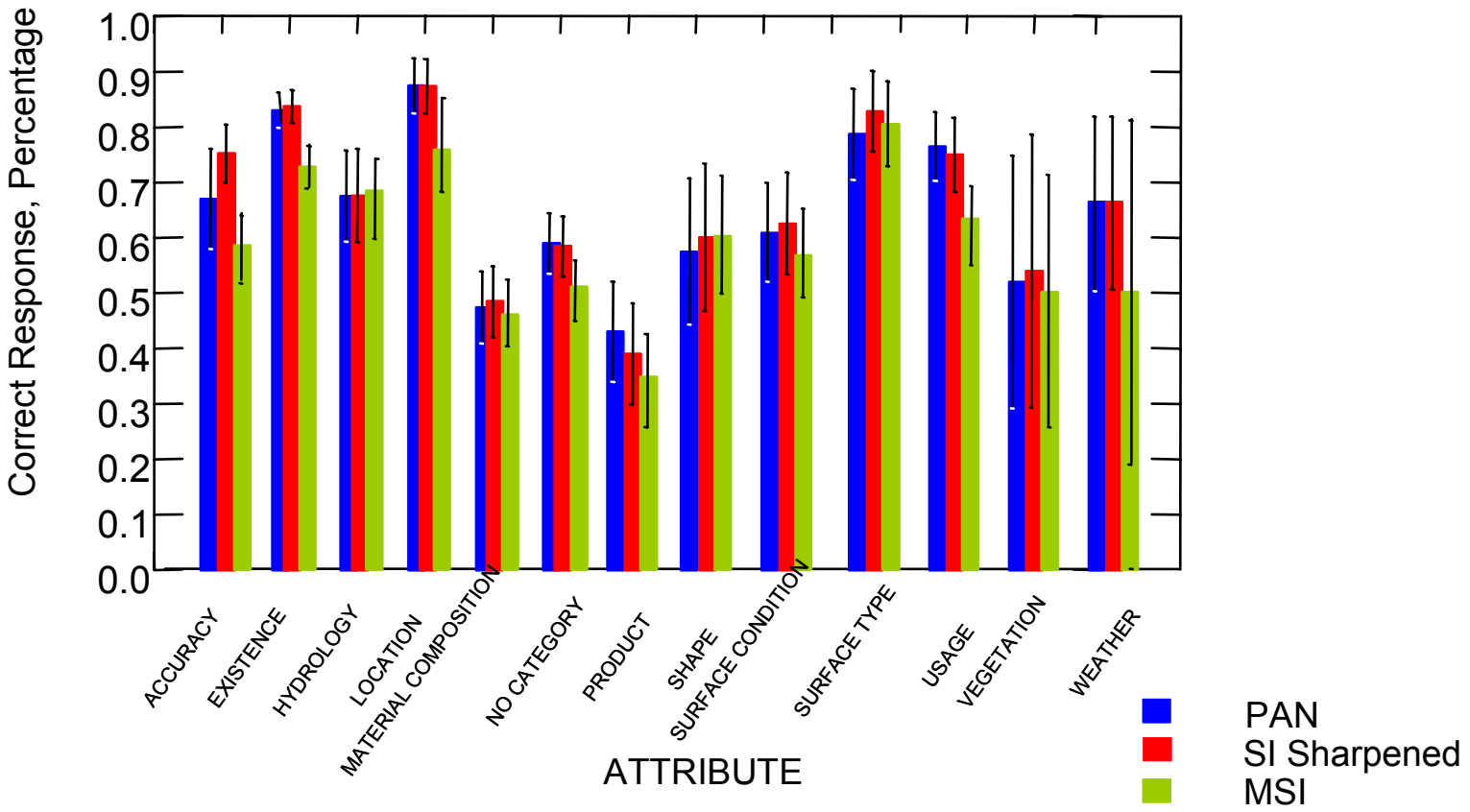
Attribute Responses

- Attribute questions solicited either a multiple-choice response or a straight "Yes" or "No."
  - Multiple-choice responses were compared to the pre-determined ground truth
  - Organized by attribute category (e.g., Accuracy, Existence, etc.)
- As with the feature extraction confidence ratings, non-normality of the attribute responses makes a meaningful analysis of variance (ANOVA) difficult

Correct Responses

- Pan and Pan-sharpened image types tracked very closely in all categories for multiple-choice responses
  - Eleven of the twelve categories in these image types had a correct response rate of 50% or higher
  - Four categories received a correct response rate of 70% and higher
  - Three received a correct response rate of 80% or higher
- The correct response rate against MS image type was the same as Pan/Pan-sharpened in three of the twelve categories
  - MSI received a correct response rate that varied from four to eight percent less than those for Pan/Pan-sharpened image types

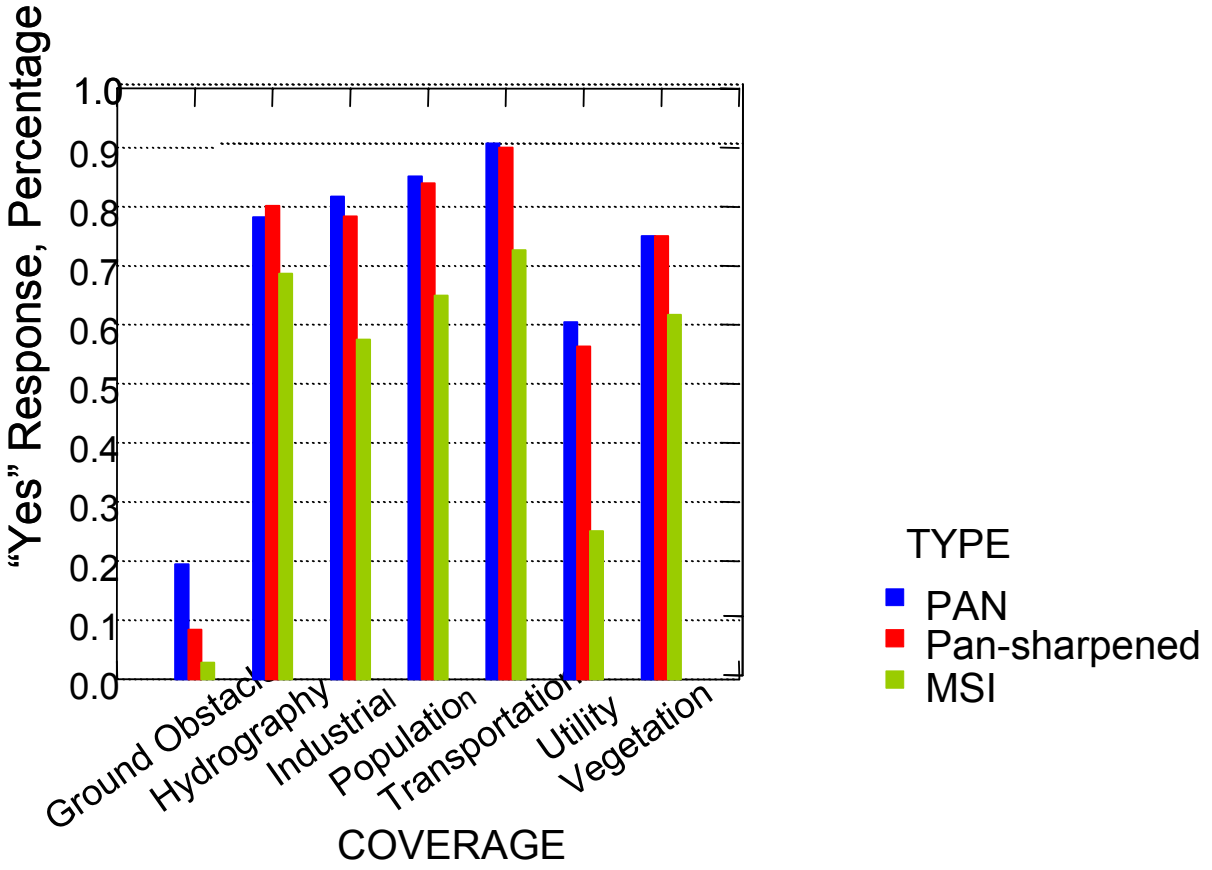
Correct Attribute Responses



Positive Responses

- Yes/no questions were not represented in all of the attribute categories, nor were they uniformly asked in all coverage categories
  - Scene dependent and addressed specific features present in the image chip
  - Subjective rating of an analyst's ability to perform a task
- Pan and Pan-sharpened image types received notably higher positive responses than MSI in all categories
- The largest differences between Pan/Pan-sharpened and MSI were in the Utility category
- The lowest positive response was for the Ground Obstacle coverage category

Positive Attribute Responses



Conclusion

- IKONOS Pan and Pan-sharpened MSI meets most requirements of cartographers in extracting features to build NIMA map products
  - Study address fundamental utility of IKONOS for creating maps to NIMA specifications
- This evaluation indicates that GIs used spectral content to a lesser amount than spatial content
  - Features from the vegetation category, for example, are extracted with essentially the same confidence for all image types, suggesting that GIs extract vegetation features based on their spatial content and tonal differences, and not on spectral content
- This likely results from a combination of factors,
  - Analyst experience with MSI (generally low)
  - Poor suitability of feature tasks derived from the FACC (written for application to panchromatic sensors) to address multispectral imagery

Acknowledgements

CCAP would like to thank the following individuals whose participation made this evaluation possible:

- Mark Bowman
- Zedric Teague
- Mike Noderer
- Pete Jekel
- Cynthia Maahs
- Kent Pemberton